## Bonneville Power Administration
## Fish and Wildlife Program FY99 Proposal

## Section 1. General administrative information

# Develop TDG Abatement Plan Of Action Using Wheels Pools And Falls Approach

**Bonneville project number, if an ongoing project** 9115

**Business name of agency, institution or organization requesting funding**
Sun Mountain Reflections

**Business acronym (if appropriate)** SMR

**Proposal contact person or principal investigator:**


| | |
|---|---|
| **Name** | Faith E. Ruffing |
| **Mailing Address** | 1907 NE 75 th Avenue |
| **City, ST Zip** | Portland, Oregon 97213 |
| **Phone** | (503) 256-8748 |
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| **Email address** | Faith.Ruffing@GTE.com |


**Subcontractors.**

| Organization | Mailing Address | City, ST Zip | Contact Name |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

**NPPC Program Measure Number(s) which this project addresses.**
5.6A, 5.6B, 5.6C, 5.6E

**NMFS Biological Opinion Number(s) which this project addresses.**
VIII.A1,2,15,18,

**Other planning document references.**

**Subbasin.**
Snake, Willamette and Rogue

**Short description.**
SMR will work with regional entities to develop a Plan of Action using a new approach to achieve TDGS water quality standard downstream of hydroelectric projects in the Columbia Basin by 2017 and provide safe continuous fish passage at these projects.

## Section 2. Key words

| Mark | Programmatic Categories | Mark | Activities | Mark | Project Types |
|---|---|---|---|---|---|
| x | Anadromous fish | | Construction | | Watershed |
| x | Resident fish | | O & M | | Biodiversity/genetics |
| | Wildlife | | Production | | Population dynamics |
| | Oceans/estuaries | x | Research | | Ecosystems |
| | Climate | x | Monitoring/eval. | X | Flow/survival |
| X | Other | | Resource mgmt | X | Fish disease |
| | | X | Planning/admin. | | Supplementation |
| | | | Enforcement | | Wildlife habitat en- |
| | | | Acquisitions | | hancement/restoration |

**Other keywords**.
"Wheels, Pools and Falls", Gas Bubble Disease, Total Dissolved Gas Saturation

## Section 3. Relationships to other Bonneville projects

| Project # | Project title/description | Nature of relationship |
|---|---|---|
| 9300802 | Symptoms of Gas Bubble Trauma due to Gas Supersaturation | Abatement of TDGS |
| 9602400 | Survival of migrating juvenile salmonids | Reducing TDGS below dams to the WQ standard and providing safe passage should improve survival |
| 9602100 | Gas bubble disease monitoring and research of juvenile salmonids | Information from this and other research will be used to assess the efffectiveness of the plan of action |
| 8740100 | Travel time and survival smolt physiology | Information from this and other research will be used to assess the efffectiveness of the plan of action |

## Section 4. Objectives, tasks and schedules

### *Objectives and tasks*

| Obj | | Task | |
|---|---|---|---|

| 1,2,3 | Objective | a,b,c | Task |
|---|---|---|---|
| I | Develop Plan of Action | a | Develop a preliminary WPF Plan of Action from existing WPF document |
| | | b | Identify questions that need to be answered to support the plan concepts |
| | | c | Develop schedule for implementation |
| 0 | Develop Research Plan | a | 1 Review available documentation being developed through the ongoing regional research effort and other sources for answers to these questions. |
| | | b | 2 Develop research proposals to answer the questions not currently being addressed. |
| | | c | Develop a Draft WPF Plan of Action for review and comment by BPA, NPPC, regional entities and the community. |
| 3 | Regional Acceptance of Plans | a | Incorporate comments and recommendations into a final WPF Plan of Action and submit to BPA and the NPPC for consideration and recommendations |
| | | b | 2 Finalize the WPF Plan of Action and submit to BPA for approval and implementation |

***Objective schedules and costs***

| Objective # | Start Date mm/yyyy | End Date mm/yyyy | Cost % |
|---|---|---|---|
| 1 | 10/1998 | 12/1998 | 30.00% |
| 2 | 10/1998 | 1/1999 | 30.00% |
| 3 | 11/1998 | 3/1999 | 40.00% |
| | | | |
| | | | TOTAL 100.00% |

**Schedule constraints.**
Review process may take longer than anticipated. Milestones are completion of plans

**Completion date.**

## Section 5. Budget

***FY99 budget by line item***

| Item | Note | FY99 |
|---|---|---|
| Personnel | | $30,000 |
| Fringe benefits | | $10,000 |
| Supplies, materials, non-expendable property | | 5,000 |
| Operations & maintenance | | |
| Capital acquisitions or improvements (e.g. land, buildings, major equip.) | | |
| PIT tags | # of tags: | |
| Travel | | |
| Indirect costs | | |
| Subcontracts | | |
| Other | | |
| **TOTAL** | | $45,000 |

***Outyear costs***

| Outyear costs | FY2000 | FY01 | FY02 | FY03 |
|---|---|---|---|---|
| Total budget | | | | |
| O&M as % of total | | | | |

## Section 6. Abstract

A new approach to abate Total Dissolved Gas Saturation (TDGS) was proposed by Faith Ruffing the sole proprietor of Sun Mountian Reflections during her tenure at the Portland District USACE. This solicitation is to fund Ms Ruffing to develop this approach into a Plan of Action with conceptual designs, research plans, schedule for plan implementation and a budget for research, analysis, testing and construction of modifications to hydroelectric projects in the Columbia basin. SMR will develop the plans and submit them to a review process by regional entities and the community. SMR will seek aproval of these plans by the BPA and the NPPC and other agencies.

## Section 7. Project description

**a. Technical and/or scientific background**.

## INTRODUCTION

Major components of the goals and objectives of the 1994 Fish and Wildlife Program (FWP)(1), NMFS Biological Opinion (BiOp)(2) and the ongoing efforts on the part of the Dissolved Gas Team (DGT)(3) are the development of a Research Plan and and a Plan of Action to abate gas supersaturation downstream of hydroelectric projects in the Columbia Basin.

Sun Mountain Reflections (SMR) proposes to work with the regional entities in the development of these plans using a new approach developed by the principle investigator (PI), Faith E. Ruffing, to reach the Water Quality Standard for Total Dissolved Gas Supersaturation (TDGS), provide continuous safe passage for anadromous fish and improve water quality for all aquatic organisms by the year 2017 while keeping the dams and the broad range of benefits they provide to the region.

The new approach, called Wheels, Pools and Falls (WPF)(4), was developed by the PI as a result of her research and analysis of the dissolved gas supersaturation problem in the Columbia Basin while serving appointment to the USACE Portland District Water Quality Section as Program Coordinator for the Dissolved Gas Compliance Program. As Program Coordinator her duties included serving as a member of the Dissolved Gas Team (DGT) and actively participating in the development of the regional Plan of Action for gas abatement in response to regulatory agency requests. These requests have recently been clarified in correspondence from EPA to the Army Corps of Engineers dated December 9, 1997(5), and in a letter from the Washington State Department of Ecology dated December 17, 1998(6).

TDGS data collected in association with the Lower Columbia River projects indicate that the water quality standard is exceeded downstream of these projects to the estuary for extensive periods of time when the quantity of spill requested by NMFS is discharged. The concentrations of TDGS are even higher during years of high runoff as experienced in 1996 and 1997. Management of the runoff to keep the TDGS concentrations as low as possible is minimally successful and is only an interim solution until major modification are made at the dams to abate gas.(7,8,9)

Several alternative designs have been suggested for gas abatement by the Dissolved Gas Abatement Study (DGAS)(10). They follow an incremental reduction approach with an uncertain end point for achieving TDGS concentrations of 110% and an extensive prototype development and testing period. The least expensive do not reduce gas more than a few percent and the alternatives that will reduce gas to the standard are very expensive and may result in other detrimental impacts to the fish. The alternatives are being compared one against another and lack a comprehensive plan to show how they will acheive the goal and the schedule for doing so. The alternative designs are determining the gas abatement reduction limits instead of the TDGS standard determining what the designs should be.

The Wheels, Pools and Falls approach uses compliance with the TDGS Standard as the goal and describes a thought process to identify the changes in design needed at the dams to achieve the goal. The WPF contains a preliminary Plan of Action resulting from this process, parts of which has been incorporated into this proposal.

## ENVIRONMENTAL PERSPECTIVE

The WPF has an environmental perspective which encompasses several objectives for increasing fish populations in the Columbia Basin related to the hydroelectric projects in the basin. These are

to comply with the TDGS standard as required by the regulatory agencies,
to provide safe and continuous passage for anadromous fish,
to improve water quality for all aquatic organisms,
to preserve the integrity of the dams and the broad range of benefits they provide to the region.

In the WPF the discussion moves the focus to a broader vision which looks to the natural condition of the ecosystem for solutions to the problems posed by the dams and the mechanical realities of the dams and incorporates this information into a comprehensive plan to abate gas which meets these other objectives. Starting with a clean canvass, broad stroke pictures of the economic, ecological, developmental and cultural needs of the region are painted. Common goals to meet those needs are set and strategies are described to reach those goals. Informational requirements are identified and hypotheses and study plans are developed and implemented to provide detailed information to test the hypotheses. A 20 year plan of action will be developed in five year increments which describes objectives and schedule of activities to reach the goals set. Cost estimates and funding sources are developed to be included in the budgetary process.

SMR proposes that using the WPF as a basic document, a plan of action can be developed and implemented that is satisfactory to the regional entities concerned with mitigating the impact the hydroelectric projects have on the salmon populations in the region. Research requirements identified in the plan can be incorporated into the research plan being developed by the DGT. The main elements in the WPF are described below.

## ENVIRONMENTAL NEEDS and GOALS

<u>Ecological</u>

comply with water quality standards, conserve and protect the water resource, the aquatic organisms and habitat, and improve fish passage and survival.

<u>Economical</u>

make most efficient use of the water resources through diversified response to regional needs for the fishery, flood control, navigation, hydropower, irrigation, and recreation.

Developmental

plan for the needs of future generations that reflect the broad diversity of the ecology, economy, and cultures of the Pacific Northwest and allow for prosperity for all

Cultural

respond to identified conflicts over the use of the Columbia River resource between the dams and the fish by solving the gas problem in such a way as to preserve the identified benefits of the dams and greatly improve the fish passage efficiency and survival of aquatic organisms to support the ecological enhancement of the Pacific Northwest.

## STRATEGIES

Describe gas production in terms of the independent variables that are functions of the TDG equation.

Determine how changes of each independent variable changes TDG concentration and what will bring TDG concentrations closer to 100 % saturation within a mile downstream of Corps projects.

Develop conceptual solutions for TDG reduction below Corps projects in the Columbia, Willamette, and Rogue River based on the equation and identify information needed to test the concept and develop a study plan.

Write a gas reduction plan for each project applying information from the studies to the hypotheses and suggest parameter limitations to be included in the proposed redesign of the projects included in the plan.

Identify benefits for the proposed gas reduction plan that apply to other environmental goals of the program.

## EQUATION

TDG concentrations below Corps projects are dependent on the discharge, the shape of the dam, the near downstream morphometry of the river, and the chemical physical quality of the water.

$$TDG = f(discharge) + f(structure) + f(morphometry) + f(quality)$$

Discharge: increased discharge over the spillway increases TDG concentrations downstream of the dams, increased discharge through the powerhouse does not increase TDG concentrations, spillway discharge can be reduced to an amount that can be diluted with powerhouse water in order to reach 110 % saturation within a mile downstream of the dams

Structure: TDG concentrations increase as the change in elevation from the forebay to the river bottom downstream of the dam increases. The depth of the forebay pool from the water surface to the crest of the dam, the distance from the crest to the water surface in the river downstream of the dam, and the depth of water in the river downstream of the dam are three components of this change in elevation. The head pressure, determined by the depth of the forebay, is important in determining the amount of energy in the packet of water being released over the spillway that must be dissipated in the river below.

Morphometry
The shape of the river bottom downstream of is important in the retention and dissipation of the gas as the water moves downstream. Deep still water retains the gas in the water at depth whereas shallow turbulent water brings the gas in the water to the surface and allows it to dissipate into the atmosphere.

Quality: Elevated TDG gas concentrations in the forebay result in these concentrations being carried through the powerhouse with little reduction eliminating the dilution capabilities of the powerhouse water.

## WHEELS, POOLS AND FALLS CONCEPT

To reduce TDG concentrations to 110 % the following options are available:

TDG reduced = f(spill) reduced + f(elevation change)reduced, f(morphometry) altered + f(TDG forebay concentrations) reduced.

Reduced spill

Spill in the quantity prescribed by the BiOp results in TDGS above the water quality standard.

Reducing elevation changes

Reducing the elevation change from the forebay to the bottom of the receiving river has the greatest potential for reducing gas production below the dams. It also has the potential of reducing other impacts to the migratory fish such as head burns and other damage due to sheer and changes in hydrostatic pressure. The height of the fall can be limited by design to a tested range of elevation changes that will not produce gas levels above 110%. The range of elevation changes will allow for a range of discharges that reflect the historical records for flows and allow for greater flexibility in operations for flood control, hydropower production, and other regional needs.

The water is released from the dam to a series of pools and falls where the height of the falls are limited by the range of elevation changes that will not produce TDG concentration in excess of the standard. The reduction in energy produced by the

reduced fall will allow the depth and size of the pools required to contain the energy of the hydraulic jump to be reduced. Water can fall into pools with a range of depths and a size that has been shown to handle the hydraulic jump. The gas produced by the initial fall can be released during the second fall and gas production by the second fall will be limited by the height of the fall. Each fall will lower the water another elevation increment and each pool will allow for the energy and gas dissipation. The number of falls and pools will depend on the combined elevation change from the forebay to the bottom of the stilling basin and the range of elevation changes that will produce TDG concentrations within the standards. The size and depth of the pools will depend on how much hydraulic energy needs to be dissipated.

Gas dissipation can be enhanced by changing the morphometry of the pools to provide a diversity of depths with deep pools to allow for sounding by the fish and shallow turbulent areas to bring the water to the surface. The interface between the last fall and pool should be integrated with the natural morphometry of the receiving river. The arrangement of the falls and pools would be such that it could be contained within the stilling basin of the project.

The elevation changes from the forebay pool surface to the crest of the dam are a significant component in the overall elevation change for each dam. At Bonneville the forebay to crest is about 50 % of the total drop, at The Dalles it is 40 % of the total drop, and at John Day it is 30 % of the total drop. Modifications of the gates or the gate wells to reduce the drop from the pool surface to the spillway crest will reduce the head pressure and the TDGS.

Morphometry of the tailrace

The TDG concentrations in the water leaving the last pool and entering the river would be less than the standard therefore the morphometry of the tailrace would remain the same.

Water quality

TDGS would be at 110% as it leaves the tailrace of the upstream dam and the TDGS would be within the standard for all but a few miles immediately downstream of the dams.

Other benefits.

Since the concentrations of TDGS below the dams will be regulated by the falls and pools, the reservoir regulators will have greater flexibility in operational decisions and can respond more directly to flood control, hydropower production and other regional needs. The fish passage could be greatly improved as the pools and the falls could provide a fish friendly passage from the tailwater to the forebay for the adults and from the forebay to the tailwater for the juveniles. The fishways now in use will be replaced with pools and falls which could extend across the entire width of the spillway. This

improved passageway may also allow for reduced spill requirement from NMFS while still improving the fish passage efficiency and survival of migratory fish in the Columbia and Snake river basins.

## WHEELS, POOLS AND FALLS STUDY PLAN

The focus of the study will be to answer the following questions.

* What is the maximum distance water with the head pressure of these dams can fall to keep TDG supersaturation within the 110 % saturation concentration?

* What is the range of maximum distances water can fall given the range of historical discharges observed at these projects or the projected capacities of these dams?

* What is the size and depth of the pools needed to contain or dissipate the energy contained in the released water given the range of historical discharges and the design capacities of the dams?

* What are the best configurations to reach the 110 % goal while minimizing the amount of material that must be deployed in the stilling basin to create the pools and falls?

* What are the best combinations of boulders, rocks, reinforced concrete or other materials to provide sufficient strength to withstand the energy while minimizing the cost of the WPF modification?

* What is the feasibility of modifying or replacing existing gate structures to accommodate water wheels to move the forebay water from the surface to the crest of the dam and using the turning wheel to run turbines?

* What design criteria need to be developed to protect aquatic organisms, especially migratory fish, from other deleterious impacts from the modification of the dams and construction of the wheels, pools and falls?

* What design criteria need to be developed to enhance the fish habitat within these modifications at the project, and in the upstream pool, and downstream tailrace?

* What are the design criteria that need to be developed to ensure that adult and juvenile fish passage efficiency is maximized through wheels, pools and falls across the full width of the spillway.

* What are the water quality impacts that need to be taken into account during construction?

* What other water quality problems, such temperature and dissolved oxygen, can be improved through these conditions can be improved upon through the WPF modifications?

* How can water resource conservation be maximized through decreased spill requirements for fish passage as a result of improvement in passage efficiency through the wheels, pools and falls?

* How much will the WPF cost?

* What are the benefits of the WPF?

* What is the value of the benefits?

* What regional funding sources are available from the multipurpose beneficiary categories to which the projects respond: flood control, navigation, hydropower production, irrigation, recreation and the fishery?

**COST**

Costs for the study, analysis, and construction of the pools and falls will be limited to $300 million for Bonneville, The Dalles and John Day.

**b. Proposal objectives**.

Objectives
I Develop Plan of Action
II Develop Research Plan
III Regional Acceptance of Plans

Products
Preliminary Plan of Action
Draft Plan of Action
Draft Research Plan
Final Plan of Action
Final Research Plan

**c. Rationale and significance to Regional Programs**.

The wheels, pools and falls approach to TDG supersaturation reduction below Corps projects will meet the ecological, economical, developmental and cultural needs and goals described above.

Compliance with water quality standards under all discharge and flow scenarios will conserve, protect and enhance the water resource and the inhabitants therein, eliminate

the need for extensive monitoring, research programs and mathematical model development to manage the TDG concentrations through operational decisions.

It will eliminate the need to barge fish, build fish ladders, or increase spill to bypass fish at the expense of other regional needs.

It will conserve the resource for other regional needs and will resolve the conflict over the resource between the fishery and the beneficial uses of the dam and enhance the benefits reaped from these projects.

A detailed comprehensive plan which identifies additional information needs and sources study plans, design criteria, contract development and award process, cost / benefit considerations and values, budget and schedule could be developed by SMR. Entities included in the regional effort could provide expertise and advice on the Wheels, Pools and Falls project through the review proceess. Some members of the Dissolved Gas Team have been apprised of the WPF approach and have encouraged SMR to submit this proposal for funding to SMR for the development of the plan. No commitment has been by any member at this time.

**d. Project history**

Not a continuing project.

**e. Methods**.

The WPF proposal is to develop a gas abatement Plan of Action and to implement that plan for the reduction of TDGS to the water quality standard below hydroelectric projects in the Columbia Basin following the Wheels, Pools and Falls approach by the year 2017. Phase I, the development of the plan will be completed in FY 1999. Phase II, plan implementation, will be dependent on Phase I and will be carried out from 2000 to 2017.

The scope of work for this proposal is limited to the development of the Plan of Action and any research plans necessary to answer questions that cannot be resolved given available information and to get it approved by the BPA and the NPPC. It does not include implementation of the plan.

<u>Objectives/Tasks</u>

I Develop Plan of Action
1 Develop a preliminary WPF Plan of Action from existing WPF document.
2 Identify questions that need to be answered to support the plan concepts.
3 Develop schedule for implementation.

II Develop Research Plan

1 Review available documentation being developed through the ongoing regional research effort and other sources for answers to these questions.
2 Develop research proposals to answer the questions not currently being addressed.
3 Develop a Draft WPF Plan of Action for review and comment by BPA, NPPC, regional entities and the community.

III Regional Acceptance of Plans
1 Incorporate comments and recommendations into a final WPF Plan of Action and submit to BPA and the NPPC for consideration and recommendations.
2 Finalize the WPF Plan of Action and submit to BPA for approval and implementation.

**f. Facilities and equipment**.

All work will be done on a computer located at SMR.

**g. References**.

1 NPPC, 1994 Columbia River Basin Fish and Wildlife Program. Sections 5.6.A, B, C, E. .
2 NMFS, 1995 Biological Opinion Sections VIII A 1, 2, 15,18.
3 Dissolved Gas Team. 1995-1998 Meeting Agendas and Minutes and Reports.
4 Ruffing, F. E., 1996.Wheels, Pools and Falls. A proposed new approach to abating TDG supersaturation in waters below Corps projects in the Columbia, Snake, and Rogue River Basins. USACE Portland District.
5 USEPA 1997 Letter to Brigadier General Griffin re water quality standards for temperature and total dissolved gas. December 9, 1997
6 Washington Department of Ecology. 1997 Letter form Eric Schlorff re Changes in the Way Ecology Issues Modifications for Dissolved Gas. December 17, 1997.
7 USACE North West Division, Dissolved Gas Monitoring in the Columbia and Snake River Basins 1994-1997.
8 Ruffing, F. E., 1996 Annual Activities Report for the Dissolved Gas Compliance Program. USACE Portland District. 1996.
9 Sun Mountain Reflections. 1997Annual Activtes Report for the Dissolved Gas Compliance Program. USACE Portland District. 1997.
10 USACE Dissolved Gas Abatement Study Phase II 30 % report. 1997.

## Section 8. Relationships to other projects

This proposal is related to the work funded under the FWP by providing a plan of action for gas abatement as required by the water quality regulatory agencies to justify the granting of waivers needed to allow for spill at basin projects as requested by the NMFS BiOp to improve fish passage. This plan of action is also required to mitigate TDGS standards violations which occur at all dams where spill is sufficient to produce TDGS in excess of 110%.

## Section 9. Key personnel

Principal Investigator: Faith E Ruffing will develop all documents, cooordinate discussion with reviewers, and review and analyze all related reports and data for this project.

Resume: Ms Ruffing hold a Bachelors degree in Biology from Case Western Reserve University, 1970, and a Masters Degree in Biology from Portland State University, 1997. Ms Ruffing has completed all of the requirements for a doctorate in Environmental Science and Applied Research except for the dissertation at Portland State University.

*Sun Mountain Reflections* is a sole proprietor firm operated since 1984 by Faith E. Ruffing.

Ms Ruffing has 30 years experience in environmental science and technical research; regulatory compliance, program development and review; urban planning and real estate development; and environmental science and planning consulting.

As principal of *SMR*, Ms Ruffing is responsible for the execution of all work. Her qualifications working experience with the U S Army Corps of Engineers, the Oregon Department of Environmental Quality, the City of Portland, Oregon Bureau of Water Works, University of Chicago, Chicago, Evanston Hospital, Northwestern University, Evanston, Illinois and Case Western Reserve University in Cleveland, Ohio.

*Sun Mountain Reflections'* clients include the U S Army Corps of Engineers, U S Department of Agriculture, City of Portland Bureau of Water Works, City of Portland Bureau of General Services and Holbrook Estates Enterprises.

Ms Ruffing's major duties at USACE included

- Developing and coordinating Total Dissolved Gas Fixed Monitoring Program for Portland District Projects in the Lower Columbia River. Developing plans of action, schedule and budget following direction from the Northwest Division office. Developing scopes of work for contractors and managing contracts.

- Developing a Database for total dissolved gas programs for incorporation into the District water quality database. Reviewing data and assembling it into display format for reports and meetings.

- Writing reports of findings of the District Dissolved Gas Compliance Program, Total Dissolved Gas Fixed Monitoring Program, and the Total Dissolved Gas section of the District Water Quality Annual Report.

- Representing the section at intra and inter agency meetings. Attending and representing the District at NMFS/ EPA Dissolved Gas Team meetings. Serving on production and review teams as necessary.

Ms Ruffing authored the following reports:

Ruffing, F. E., 1996.Wheels, Pools and Falls. A proposed new approach to abating TDG supersaturation in waters below Corps projects in the Columbia, Snake, and Rogue River Basins. USACE Portland District.

Ruffing, F. E., 1996 Annual Activities Report for the Dissolved Gas Compliance Program. USACE Portland District. 1996.

Sun Mountain Reflections. 1997Annual Activtes Report for the Dissolved Gas Compliance Program. USACE Portland District. 1997

## Section 10. Information/technology transfer

Information can be transferred via E mail, internet, fax, floppy disc or hard copy.